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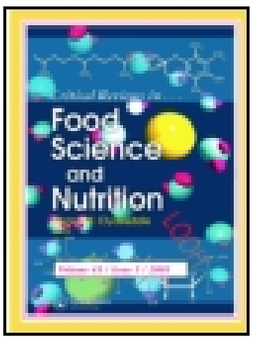

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Identification of behavior change techniques applied in interventions to improve cooking skills and food skills among adults

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ABSTRACT

Background: Cooking and food skills interventions have grown in popularity; however, there is a lack of transparency as to how these interventions were designed, highlighting a need to identify and understand the mechanisms of behavior change so that effective components may be introduced in future work. This study critiques cooking and food skills interventions in relation to their design, behavior change techniques (BCTs), theoretical underpinnings, and outcomes.

Methods: A 40-item CALO-RE taxonomy was used to examine the components of 59 cooking and food skills interventions identified by two systematic reviews. Studies were coded by three independent coders.

Results: The three most frequently occurring BCTs identified were #1 *Provide information on consequences of behavior in general*; #21 *Provide instruction on how to perform the behavior*; *and* #26 *Prompt Practice*. Fifty-six interventions reported positive short-term outcomes. Only 14 interventions reported long-term outcomes containing BCTs relating to information provision.

Conclusion: This study reviewed cooking and food skills interventions highlighting the most commonly used BCTs, and those associated with long-term positive outcomes for cooking skills and diet. This study indicates the potential for using the BCT CALO-RE taxonomy to inform the design, planning, delivery and evaluation of future interventions.

Abbreviations: BCT: behavior change technique; CS: cooking skills; FS: food skills

KEYWORDS
Cooking skills; interventions; diet; behavior change techniques

Introduction

Cooking and food skills interventions have resulted in improved diet and health outcomes (Roberts and Barnard, 2005; Blake et al., 2011; Michie et al., 2011; McGowan et al., 2017; Oggioni et al., 2015; Vernarelli et al., 2015). However, there is a lack of clarity and understanding regarding the "active components" or discrete behavior change techniques used within these interventions *(referred to as BCTs from this point onwards)*. Furthermore, there is limited understanding of how the design of cooking and food skills interventions impact on their effectiveness outcomes, as well as the role played by theoretical frameworks in promoting behavior change in this domain (Roberts and Barnard, 2005). This study defines cooking skills as "a set of mechanical or physical skills used in meal preparation" (McGowan et al., 2017); however, as domestic cooking involves broader, more complex processes, food skills should also include perceptual meal planning, food acquisition, organizational and creative skills, as well as those relating to nutrition and food hygiene (McGowan et al., 2017).

There is considerable evidence linking poor dietary intake with multiple chronic illnesses worldwide such as diabetes, cancer, and cardiovascular disease (McGowan et al., 2017; Oggioni et al., 2015; Vernarelli et al., 2015). The ability to cook and prepare meals from basic ingredients at home is posited and demonstrated as an integral component in the consumption of a healthy diet and diet quality (McGowan et al., 2017). Cooking and meal preparation have become increasingly important in Western countries where food consumption patterns have

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What is already known on this subject?

Cooking and food skills interventions are growing in popularity. There is a pressing need to better understand the effective components within these behavior change interventions. Identifying and analyzing behavior change techniques (BCTs) within interventions are now possible using a published, reliable, taxonomy of techniques.

What this study adds?

The most common BCTs used within cooking and food skills interventions among adults were: (1) providing information; (2) providing instruction; (3) demonstrating behaviors; and (4) providing opportunities to practice. Interventions containing all four elements within one intervention achieved behavior change in cooking and diet beyond three months. Incorporating these findings in future cooking and food skills interventions and robustly testing their effectiveness will advance the understanding of behavior change and improve public health outcomes.

changed (Blake et al., 2011) with family-centered mealtimes declining (Caraher et al., 1999), and lifestyles and workloads increasing, resulting in a decrease in domestic cooking skills, time spent in meal preparation, and an increase in fast food consumption (Mintel, 2012). Recent cross-sectional studies report a link between greater consumption of convenience and fast food and poorer health outcomes (Burgoine et al., 2014). In order to address these issues, as well as the escalating cost of health-related illnesses (Foresight, 2007), cooking and food skills interventions targeting dietary outcomes have grown in popularity within the public health sector (Caraher, 2012).

Michie et al. (2011) published a refined 40-item CALO-RE taxonomy (Michie et al., 2011) of BCT used to characterize the active components of inventions (e.g., barrier identification, goal setting and feedback on performance) to understand "what works" in a given circumstance, or within a particular population group, maximizing future intervention efficacy (Michie et al., 2009). In addition, a robust approach to "*standardizing*" behavioral interventions with regard to design, content, setting, and population group has been advocated by researchers to identify factors which lead to successful behavior change (Michie et al., 2009).

In light of the above this paper use the CALORE taxonomy (Michie et al., 2011) to review existing cooking and food skills interventions to identify the BCTs employed. In addition, the study examined current cooking and food skills interventions in terms of their sample, theoretical underpinnings, design, and long-term and short-term outcomes.

Method search strategy

Cooking and food skills interventions were extracted from 2 worldwide systematic reviews, Reicks et al. (2014) and Reicks et al. (Under review). Both reviews were selected due to their recency, relevance, and robustness in design. Both systematic reviews (Reicks et al., 2014; Reicks et al., Under review) provided an international perspective on cooking skills and food skills interventions with adults. The first review (Reicks et al., 2014) identified relevant research published between January 1980 and December 2011. A total of 319 journal articles were identified (excluding duplicates) and screened which resulted in 25 studies meeting the inclusion criteria (discussed later). The second review (Reicks et al., Under review) identified relevant research between January 2012 and March 2016. A total of 2365 journal articles were identified (excluding duplicates) and screened which resulted in 34 studies meeting the inclusion criteria. Both review studies used the same keyword searches across three electronic databases (OVID MEDLINE, Agricola, and Web of Science) *(please refer to original papers for more details)*.

Screening

Full text papers and reports which could not be accessed via online databases and web searches were provided by the author of the review papers and included in the present sample. All studies were screened by Reicks et al. (Reicks et al., 2014; Reicks et al., Under review) against the 6-point inclusion criteria detailed below. From both reviews, a total of 59 papers on community cooking and food skills interventions with adults were identified.

Eligibility

The eligibility of inclusion in the present study was as follows:

1. Population: focus on adults (18 years+).
2. Intervention: any that targeted the development of cooking skills/food skills with a hands on or demonstration/observation cooking component.
3. Outcomes: reported behavioral outcomes relevant to the intervention target i.e., health, dietary, and psychological outcomes.
4. Date: published after January 1980.
5. Language: published in the English language.
6. Duplication: in cases with multiple publications on the same study (*in this case the paper with the most comprehensive explanation of the methodology and results was used, e.g., Condrasky "Cook with a Chef" Intervention*).

Data extraction

All studies were analyzed and the following information extracted: country, target population, sample size, intervention purpose, design, theoretical underpinnings informing the design of the intervention, primary and/or secondary outcomes (i.e., pre and/or post measures), and any reported long-term outcomes (i.e., post 3 months). Interventions were then coded using Michie et al.'s (2011) CALO-RE taxonomy (Michie et al., 2011) BCTs were mapped where identifiable according to cooking skills (i.e., the mechanical process of cooking, chopping, etc.) and food skills (i.e., perceptual planning, acquisition, organizational and creative skills, as well as those relating to nutritional knowledge and food hygiene).

On examination of specific BCTs within the CALO-RE taxonomy (Michie et al., 2011), certain definitions required further clarification and standardization to relate the taxonomy specifically to cooking and food skills interventions. To minimize any discrepancies surrounding inter-coder agreement in relation to the interpretation of each BCT, a codebook of definitions was discussed and agreed upon with two researchers involved in the coding process (DS and FL). In addition, the coders contacted the taxonomy authors for clarity over any discrepancies. For example, BCT #26 *Prompt Practice* explicitly states "prompt the person to rehearse and repeat the behavior or preparatory behaviors numerous times." However, for the purposes of this study it was agreed (with the taxonomy authors) to extend the definition of this BCT to include the carrying out of a practical task relating to cooking skills or food skills even once (Michie et al., 2011). A third coder (LH) reviewed all interventions and codes to ensure consistency.

Data analysis

Each research paper was read several times to gain a full understanding of the nature of the intervention. A deductive coding approach was applied using the taxonomy (Michie et al., 2011) to identify the total number of BCTs within each intervention.

The methodology and results of each paper were scrutinized and the CALO-RE framework was applied. Each BCT was then inspected for overlap and to ensure that the correct classification was made. The papers were independently coded by the first researcher (DS) who previously had undergone BCT coding training. To ensure inter-coder reliability, a sample of approximately 50% of interventions were independently coded by FL, then 10% of the full sample coded by a third researcher (LH). BCT outcomes were subsequently cross-mapped between coders and any discrepancies were discussed and reconciled. Results were collated and summarized so that the intervention outcomes could be compared with specific BCTs or combinations of BCTs identified (see Table 1).

Results

Overall, the results displayed some commonalities among the interventions relating to intervention design, BCTs used, and theoretical underpinnings reported.

Intervention design

A total of 59 cooking and food skills interventions were included within the present study and are summarized in Table 1. Overall, 24 interventions included mainly practical cooking sessions to develop cooking skills and 35 interventions focused on wider food skills issues, to include promoting nutritional knowledge, accessing healthy ingredients, and budgeting as a means to change dietary behavior with some cooking skills teaching. Of the 59 interventions included in this study, 31 were conducted in the United States (McMurry et al., 1991; Auld and Fulton, 1995; Hermann et al., 2000; Levy and Auld, 2004; Brown and Hermann, 2005; Chapman-Novakofski and Karduck, 2005; Newman et al., 2005; Woodson et al., 2005; Lacey, 2007; Shankar et al., 2007; Swindle et al., 2007; Clifford et al., 2009; Brown and Richards, 2010; Condrasky et al., 2010; Hanson et al., 2011; Wunderlich et al., 2011; Archuleta et al., 2012; Carmody et al., 2012; Francis, 2012; Bielamowicz et al., 2013; Condrasky et al., 2013; Flynn et al., 2013; Rustad and Smith, 2013; Goheer et al., 2014; Hearst et al., 2014; May et al., 2014; Mayfield and Graves, 2014; Peters et al., 2014; Adam et al., 2015; Anderson et al., 2015; Greenlee et al., 2015), 6 in the United Kingdom (McKellar et al., 2007; Wrieden et al., 2007; Kennedy et al., 2008; Davies et al., 2009; Penn et al., 2013; Garcia et al., 2014), 5 in Australia (Foley and Pollard, 1998; Abbott et al., 2010; Michie et al., 2011; Herbert et al., 2014; Hossain et al., 2015), 4 in Canada (Flesher et al., 2011; Sorensen et al., 2011; Archuleta et al., 2012; Dasgupta et al., 2012), 3 in Scandinavia (Karvetti, 1981; Pluss et al., 2011; Vadstrup et al., 2011), 2 in Japan (Kitaoka et al., 2013; Kwon et al., 2015), 2 in Italy (Dasgupta et al., 2012), and 1 each in China (Chung and Chung, 2014), India (Balagopal et al., 2012), Indonesia (Fahmida et al., 2015), South America (Jacoby et al., 1994), Netherlands (Poelman et al., 2015), and the Republic of Ireland (McGorrian et al., 2015).

Of the 59 intervention designs, 12 were randomized controlled trials (RC) (Karvetti, 1981; Levy and Auld, 2004; Clifford et al., 2009; Flesher et al., 2011; Pluss et al., 2011; Sorensen et al., 2011; Carmody et al., 2012; Peters et al., 2014; Greenlee et al., 2015; Kwon et al., 2015; Poelman et al., 2015; McGorrian et al., 2015), 12 were non-randomized controlled trials (NRC) (Jacoby et al., 1994; Auld and Fulton, 1995; McKellar et al., 2007; Wrieden et al., 2007; Kennedy et al., 2008; Archuleta et al., 2012; Balagopal et al., 2012; Bielamowicz et al., 2013; Kitaoka et al., 2013; Chung and Chung, 2014; Adam et al., 2015; Anderson et al., 2015), and the remaining 35 studies were pre/post or post evaluations only. Sample sizes ranged from 21 participants to 7422 participants with a mean of 359 participants. The target population for each intervention varied and was coded into 5 main groups: 16 interventions targeted low-income and vulnerable groups (e.g., the elderly) (Jacoby et al., 1994; Auld and Fulton, 1995; Ranson, 1995; Foley and Pollard, 1998; Keller et al., 2004; Swindle et al., 2007; Wrieden et al., 2007; Kennedy et al., 2008; Hanson et al., 2011; Flynn et al., 2013; Rustad and Smith, 2013; Chung and Chung, 2014; Garcia et al., 2014; May et al., 2014; Anderson et al., 2015; Hossain et al., 2015; Kwon et al., 2015); 20 interventions targeted groups with health needs (e.g., recovering cancer patients or "cancer survivors") (Karvetti, 1981; Hermann et al., 2000; Chapman-Novakofski and Karduck, 2005; Newman et al., 2005; McKellar et al., 2007; Flesher et al., 2011; Pluss et al., 2011; Sorensen et al., 2011; Vadstrup et al., 2011; Archuleta et al., 2012; Carmody et al., 2012; Dasgupta et al., 2012; Villarini et al., 2012; Bielamowicz et al., 2013; Kitaoka et al., 2013; Penn et al., 2013; Greenlee et al., 2015; McGorrian et al., 2015; Poelman et al., 2015; Villarini et al., 2015); 14 interventions targeted the general adult population (including students) (Hermann et al., 2000; Levy and Auld, 2004; Brown and Hermann, 2005; Lacey, 2007; Clifford et al., 2009; Brown and Richards, 2010; Wunderlich et al., 2011; Balagopal et al., 2012; Francis, 2012; Goheer et al., 2014; Herbert et al., 2014; Peters et al., 2014; Adam et al., 2015); 6 interventions targeted specific cultural groups (e.g., Aboriginal adults) (Woodson et al., 2005; Shankar et al., 2007; Davies et al., 2009; Abbott et al., 2010; Condrasky et al., 2013; Hearst et al., 2014); and 3 interventions targeted families (Condrasky et al., 2010; Mayfield and Graves, 2014; Fahmida et al., 2015). Of the 59 interventions, 40 interventions recruited a mixed gender sample, 14 interventions recruited a female only sample, and 5 interventions recruited a male only sample (see Table 1).

With regard to intervention duration, 6 included only 1 session (Jacoby et al., 1994; Lacey, 2007; Brown and Richards, 2010; Condrasky et al., 2013; Mayfield and Graves, 2014; Poelman et al., 2015); 13 interventions ran between 2 and 4 sessions (Ranson, 1995; Foley and Pollard, 1998; Levy and Auld, 2004; Chapman-Novakofski and Karduck, 2005; Clifford et al., 2009; Pluss et al., 2011; Vadstrup et al., 2011; Archuleta et al., 2012; Francis, 2012; Bielamowicz et al., 2013; Rustad and Smith, 2013; Chung and Chung, 2014; Hearst et al., 2014); 17 interventions included 5–7 sessions (McMurry et al., 1991; Auld and Fulton, 1995; Woodson et al., 2005; McKellar et al., 2007; Shankar et al., 2007; Swindle et al., 2007; Wrieden et al., 2007; Condrasky et al., 2010; Hanson et al., 2011; Kitaoka et al., 2013; May et al., 2014; Goheer et al., 2014; Adam et al., 2015; Fahmida et al., 2015; McGorrian et al., 2015; Villarini et al., 2015); 10 interventions included between 8 and 10 sessions (Hermann et al., 2000; Keller et al., 2004; Brown and

Table 1. Summary of cooking intervention outcomes.

Intervention	Country	Method	Sample Size	Target Pop.	Gender	Number of Sessions	Type	Aim	Results Reported 1 = Quant 2 = Qual 3 = Mixed	Outcomes 1 = Health 2 = Dietary Behavior 3 = Psych.	Aim met? 1 = Yes 2 = NO	Positive Short-Term (Pre & Post-Measure) 1 = Yes 2 = NO	Positive Long Term Effects >3mths 1 = Yes 2 = NO	Theory Explicit in the Study Design
Brown and Richards (2010)	US	Pre/post	616	General pop.	Mixed	1	CS	To increase variety of meals	1	3	1	1	2	none
Lacey (2007)	US	Post	55	General pop.	Female	1	CS	To introduce a range of cereal products	1	3	1	1	2	none
Abbott et al. (2010)	AUS	Post	23	Cultural group	Mixed	29	FS	To apply NK and FS to daily lives and the wider family	2	2,3	2	2	2	none
Davies et al. (2009)	UK	Pre/post	46	Cultural group	Mixed	28	FS	To engage Asian groups to healthy eating practices	3	3	1	1	1	none
Swindle et al. (2007)	US	Pre/post	53	Low-income & vulnerable groups	Mixed	6	FS	Measure the impact of "eating right"	1	3	1	1	1	EL
Shankar et al. (2007)	US	Pre/post	212	Cultural group	Female	6	FS	Increase FV consumption among African American women	1	2,3	1	1	2	SET
Newman et al. (2005)	US	Pre/post	739	Health needs	Female	12	FS	To introduce plant based foods	1	2	1	1	1	SCT
Woodson et al. (2005)	US	Pre/post	485	Cultural group	Mixed	6	FS	Promotion of nutritional info	1	3	1	1	2	none
Brown and Hermann (2005)	US	Pre/post	602	General pop.	Mixed	8	FS	Increase FV in young adults	1	2	1	1	1	none
Keller et al. (2004)	CAN	Pre/post	29	Low-income & vulnerable groups	Male	8	CS	Increase nutritional well-being of older males	3	3	1	1	1	none
(Foley and Pollard (1998)	AUS	Pre/post	612	Low-income & vulnerable groups	Mixed	4	FS	Reduce cost of healthy household shopping	1	2,3	1	1	2	none
Ranson (1995)	AUS	Pre/post	60	General pop.	Male	4	CS	Promote cooking confidence in men	3	3	1	1	2	none
Chapman-Novakofski and Karduck (2005)	US	Pre/post	239	Health needs	Mixed	3	NK	Increase food choices to those with diabetes	1	3	1	1	2	SCT
Hermann et al. (2000)	US	Pre/post	76	General pop.	Mixed	8	CS	Promote nutritional application in food choices and cooking	1	1,2	1	1	2	SCT
McMurry et al. (1991)	US	Pre/post	336	Health needs	Mixed	6	FS	Promote nutritional information and its application	1	3	1	1	2	none
Condrasky et al. (2010)	US	Pre/Post	29	Family	Mixed	6	CS	Formative analysis of the "Cooking with a Chef" project	3	3	1	1	2	SCT
Wrieden et al. (2007)	UK	NRC	113	Low-income & vulnerable groups	Mixed	7	CS	Using "Cookwell" to promote healthy eating	2	3	1	1	2	none

Kennedy et al. (2008)	UK	NRC	26	Low-income & vulnerable groups	Female	10	FS	Increase NK of domestic food practices	3	2,3	1	1	2	none
Auld and Fulton (1995)	US	NRC	29	Low-income & vulnerable groups	Female	5	CS	Increase the use of commodity foods	1	2	1	1	2	SLT
Jacoby et al. (1994)	S Am	NRC	143	Low-income & vulnerable groups	Female	1	FS	Improve awareness of food preparation practices in terms of weaning	1	3	1	1	2	none
McKellar et al. (2007)	UK	NRC	130	Health needs	Female	6	FS	Investigate the impact of a Mediterran-ean style diet on patients with arthritis	1	1,2	1	1	2	none
Clifford et al. (2009)	US	RC	101	General pop.	Mixed	4	FS	Assess the impact of TV cooking shows on cooking motivation & learning	1	3	1	1	2	SCT
Levy and Auld (2004)	US	RC	65	General pop.	Mixed	4	CS	Determine if cooking sessions improve knowledge attitudes, efficacy, and behavior	1	3	1	1	2	SLT
Karvetti (1981)	SCD	RC	272	Health needs	Male	15	FS	Assess the benefit of cooking dem. on NK & self-efficacy	1	3	1	1	2	none
Flesher et al. (2011)	CAN	RC	40	Health needs	Mixed	17	CS	Measure the impact/ individual nutritional advice, cooking and exercise classes vs standard care	2	3	1	1	2	none
Adam et al. (2015)	US	NRC	7422	General pop.	Mixed	5	CS	Online course/ cooking instruction to improve eating behavior	1	3	1	1	2	SCT
Anderson et al. (2015)	US	NRC	95	Low-income & vulnerable groups	Mixed	16	CS	Cooking and exercise to build self-efficacy and build intrinsic motivation for health	1	1,3	1	1	2	none
Archuleta et al. (2012)	US	NRC	117	Health needs	Mixed	3	CS	Do cooking classes improve nutrient intake in people with type 2 diabetes	1	1,2,3,	1	1	2	SCT
Balagopal et al. (2012)	India	NRC	1638	General pop.	Mixed	10	FS	To test the impact of a 6 month community based diabetic prevention program in rural India	3	1,2,3	1	1	2	none
Bielamowicz et al. (2013)	US	NRC	2853	Health needs	Mixed	3	FS	Determine the impact of a community diabetes project in improving cooking practices	3	2,3	1	1	2	none
Carmody et al. (2012)	US	RC	36	Health needs	Male	11	CS	Determine the impact of diet on prostate cancer	1	1,2,3	1	1	2	None
Chung and Chung (2014)	China	NRC	60	Low-income & vulnerable groups	Mixed	3	CS	The effect of a cooking class n on the diets of the elderly	3	1,3	1	1	2	None

(*Continued on next page*)

Table 1. (*Continued*)

Intervention	Country	Method	Sample Size	Target Pop.	Gender	Number of Sessions	Type	Aim	Results Reported 1 = Quant 2 = Qual 3 = Mixed	Outcomes 1 = Health 2 = Dietary Behavior 3 = Psych.	Aim met? 1 = Yes 2 = NO	Positive Short-Term (Pre & Post-Measure) 1 = Yes 2 = NO	Positive Long Term Effects >3mths 1 = Yes 2 = NO	Theory Explicit in the Study Design
Condrasky et al. (2013)	US	Pre/post	114	Cultural group	Mixed	1	FS	Assess a modified version of "cooking with a chef" program	3	3	2	1	2	SCT
Dasgupta et al. (2012)	CAN	Pre/post	75	Health needs	Mixed	15	FS	Improve Glycemic and blood pressure	1	1	1	1	2	None
Fahmida et al. (2015)	Insa	Pre/post	494	Family	Female	6	FS	Improving NK and feeding practices	1	1,2,3	1	1	2	None
Flynn et al. (2013)	US	Pre/post assessment	63	Low-income & vulnerable groups	Mixed	6	FS	Improve food purchases and eating habits	1	1,2	1	1	1	None
Francis (2012)	US	Pre/post assessment	21	General pop.	Mixed	4	NK	Increase familiarity to the "heart healthy lifestyle"	1	1,3	1	1	1	SMT
Garcia et al. (2014)	UK	Pre/post	44	Low-income & vulnerable groups	Mixed	8	CS	Evaluate impact of program on confidence and food eating habits	1	2,3	1	1	1	None
Goheer et al. (2014)	US	Pre/post	78	General pop.	Mixed	6	FS	Nutrition class to reduce obesity and risk of heart attack in firefighters	1	2,3	1	1	2	None
Greenlee et al. (2015)	US	RCT	70	Health needs	Female	9	FS	Examine the effect of culturally-based approach to dietary change	1	2	1	1	1	None
Hanson et al. (2011)	US	Pre/post	40	Low-income & vulnerable groups	Mixed	7	FS	Investigate the impact of nutrition knowledge on diet	3	2	1	1	2	None
Hearst et al. (2014)	US	Pre/post	25	Cultural group	Female	4	CS	Parent-centered work to increase fruit and veg intake	3	2	1	1	2	None
Herbert et al. (2014)	AUS	Pre/post	140	General pop.	Mixed	10	FS	The impact of Jamie's Ministry of Food to healthy cooking	3	2,3	1	1	1	None
Hossain et al. (2015)	AUS	Pre/post	176	Low-income & vulnerable groups	Mixed	not stated	CS	Impact of the Red Apple Healthy Lifestyles program	1	2,3	1	1	1	None
Kitaoka et al. (2013)	Japan	NRC	71	Health needs	Male	5	CS	Impact of cooking classes on lifestyle change	1	3	1	1	2	None
Kwon et al. (2015)	Japan	RCT	89	Low-income & vulnerable groups	Female	12	FS	The impact of physical exercise and nutrition classes	3	3	1	1	2	None
May et al. (2014)	US	Pre/post	45	Low-income & vulnerable groups	Mixed	6	CS	Online curriculum to improve cooking and shopping skills	3	2,3	1	1	2	None

Mayfield and Graves (2014)	US	Pre/post	446	Family	Mixed	1	FS	Increase nutrition knowledge and dietary behaviors	1	3	1	1	2	None
McGorrian et al. (2015)	ROI	RCT	116	Health needs	Mixed	5	CS	Examine the effects of a novel cookery skills class on BMI	1	1	1	2	2	None
Penn et al. (2013)	UK	Pre/post	218	Health needs	Mixed	20	CS	To assess feasibility of a cooking skills class on lifestyle change	3	1,2	1	1	1	None
Peters et al. (2014)	US	RCT	71	General pop.	Female	24	CS	Study the pattern of dietary change following a cooking skills class	1	2	1	1	1	None
Pluss et al. (2011)	SCD	RCT	224	Health needs	Mixed	3	CS	Investigate the long-term effect of expanded cardiac rehab on patients	1	1	1	1	1	None
Poelman et al. (2015)	NL	RCT	278	Health needs	Mixed	1	FS	Determine the effect of the PortionControl @HOME on BMI	1	1,2	1	1	2	None
Rustad and Smith (2013)	US	Pre/post	118	Low-income & vulnerable groups	Female	3	FS	Assess the impact of a short-term nutritional class on dietary behavior	1	2,3	1	1	2	None
Sorensen et al. (2011)	CAN	RCT	56	Health needs	Mixed	10	FS	Impact of cc on BMI	1	1	1	1	2	None
Vadstrup et al. (2011)	SCD	Pre/post	143	Health needs	Mixed	3	FS	Investigate effects of group- rehab vs individual counseling	1	1,3	1	2	2	None
Villarini et al. (2012)	Italy	Pre/post	96	Health needs	Female	not stated	FS	Investigate the impact of a dietary class on BMI	1	1	1	1	2	None
Villarini et al. (2015)	Italy	Pre/post	186	Health needs	Mixed	5	FS	Investigate the effect of the health education on lifestyle Metabolic Syndrome	1	1	2	2	2	None
Wunderlich et al. (2011)	US	Pre/post	355	General pop.	Mixed	8	FS	Investigate the impact of NK on dietary behavior	1	1,2	1	1	2	None

Key

AUS	Australia	SAM	South America	RCT	Randomized control test	SET	Social ecology theory
CAN	Canada	SCD	Scandinavia	NRCT	Non-Randomized control test	SLT	Social learning theory
INSA	Indonesia	UK	United Kingdom	SCT	Social cognitive theory	SMT	Social marketing theory
NL	Netherlands	US	United States of America	EL	Experiential learning theory		
ROI	Republic of Ireland						

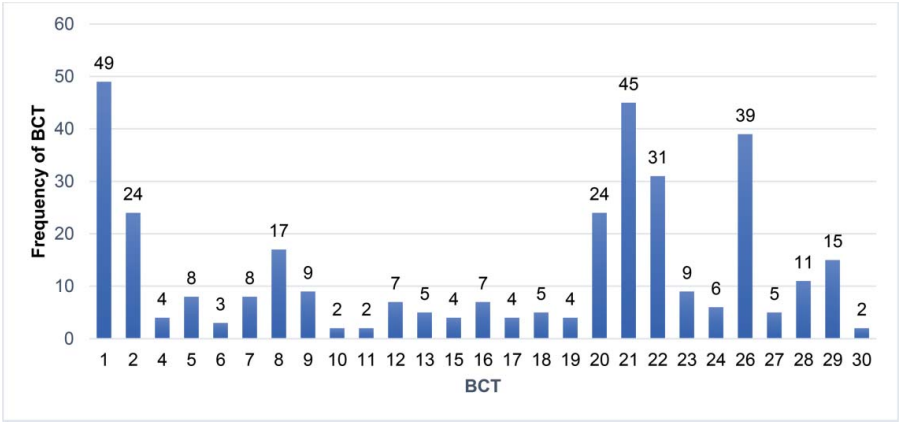

Figure 1. Frequency of identified BCTs across all 59 cooking interventions.

Hermann, 2005; Kennedy et al., 2008; Wunderlich et al., 2011; Balagopal et al., 2012; Kitaoka et al., 2013; Garcia et al., 2014; Herbert et al., 2014; Greenlee et al., 2015); 11 interventions included 11 or more sessions (Karvetti, 1981; Newman et al., 2005; Davies et al., 2009; Abbott et al., 2010; Flesher et al., 2011; Carmody et al., 2012; Dasgupta et al., 2012; Penn et al., 2013; Peters et al., 2014; Anderson et al., 2015; Kwon et al., 2015); and 2 interventions did not disclose this information (Villarini et al., 2012; Hossain et al., 2015).

BCTs identified across interventions

BCTs were identifiable in all 59 studies; employing between 1 and 11 of the 40 BCTs, though none explicitly reported intervention techniques as "BCTs." Thirteen interventions incorporated less than 4 BCTs (McMurry et al., 1991; Lacey, 2007; Brown and Richards, 2010; Hanson et al., 2011; Pluss et al., 2011; Archuleta et al., 2012; Villarini et al., 2012; Herbert et al., 2014; Adam et al., 2015; Anderson et al., 2015; Hossain et al., 2015; Kwon et al., 2015; Villarini et al., 2015); 21 interventions included 4–6 BCTs (McMurry et al., 1991; Foley and Pollard, 1998; Levy and Auld, 2004; McKellar et al., 2007; Shankar et al., 2007; Swindle et al., 2007; Wrieden et al., 2007; Condrasky et al., 2010; Sorensen et al., 2011; Vadstrup et al., 2011; Wunderlich et al., 2011; Dasgupta et al., 2012; Bielamowicz et al., 2013; Flynn et al., 2013; Kitaoka et al., 2013; Chung and Chung, 2014; Garcia et al., 2014; Hearst et al., 2014; Mayfield and Graves, 2014; McGorrian et al., 2015; Poelman et al., 2015); 21 interventions between 7 and 10 BCTs (Jacoby et al., 1994; Auld and Fulton, 1995; Ranson, 1995; Keller et al., 2004; Chapman-Novakofski and Karduck, 2005; Newman et al., 2005; Woodson et al., 2005; Kennedy et al., 2008; Clifford et al., 2009; Pluss et al., 2011; Balagopal et al., 2012; Carmody et al., 2012; Francis, 2012; Condrasky et al., 2013; Penn et al., 2013; Rustad and Smith, 2013; Goheer et al., 2014; Peters et al., 2014; Anderson et al., 2015; Fahmida et al., 2015; Greenlee et al., 2015); and three interventions incorporated 11 BCTs (Karvetti, 1981; Brown and Hermann, 2005; Flesher et al., 2011). The following BCTs were not used because they were not applicable to the cooking skills interventions chosen for this analysis: BCTs# 3, 14, 25, and 31–40. As illustrated in Figure 1, the top 6 BCTs most frequently used across the 59 interventions were (in descending order): BCT#1 *Provide information on consequences of behavior in general.*

Many interventions applied general information such as nutritional education to meet the needs of the individual. For example, the "*Eating Right*" intervention promotes the instructor's role as facilitating experiences to meet the needs of the learner and their prior experiences (Woodson et al., 2005). BCT#21 *Provide instruction on how to perform the behavior* was the second highest ranking BCT identified. Many of the practical cooking interventions used recipes and methods which could realistically be replicated in the home setting, e.g., in offering advice on inexpensive ingredients which may be sourced easily within participants own communities (Brown and Hermann, 2005; Newman et al., 2005). Thirdly, BCT#26 *Prompt practice,* e.g., prompting individuals and groups to take part in practical cooking sessions. Fourthly, BCT#*22 Model or demonstrate the behavior*, where cooking group facilitators may demonstrate a cooking method to promote learning. BCTs #20 and #2 jointly ranked in fifth place. BCT#20 *Provide information on where and when to perform the behavior.* In addition to offering information on how to carry out food skills, these interventions suggested where to carry out the behavior. This was illustrated in the "Food Cent$" sessions advise participants how to carry out food skills and where to access inexpensive ingredients (Keller et al., 2004). BCT#2 *Provide information on consequences of behavior to the individual*; e.g., during the "Cookwell Programme" (Wrieden et al., 2007), participants were offered nutritional information, to include the consequences of excess saturated fat and sugar on their personal diet and lifestyle. Lastly BCT #8 *Identify barriers/problem solving* where participants were encouraged to consider barriers to behavioral change then problem solve to overcome issues preventing behavioral change (see Figure 1). The "Friends with Food Programme" (Kennedy et al., 2008) was a nutritional education program which encouraged a sample of low income women to plan and prepare familiar family meals. Following sessions on nutrition and healthy eating, a problem solving discussion was facilitated on what prevents individuals from cooking healthy meals at home as well as considering ways in which barriers such as financial restrictions could be overcome.

BCTs identified within interventions and related outcomes

Each intervention contained 1–11 BCTs (mean 7.4 BCTs; mode 5 BCTs) aimed to promote behavior change (see Table 2). Across the interventions, BCTs #1 and #2 related to information provision commonly appeared together (23 out of 59 interventions). BCT#1 related to providing general information on the consequences of the behavior, whereas BCT#2 extended this by providing information on the consequences of the behavior specifically related to the individual, i.e., tailored or personally relevant information. It was also common for BCT#20 and BCT#21 to be used together with an intervention (21 out of 59 studies), where BCT#20 was related to information on where and when to perform a behavior and BCT#21 was based on providing instruction on how to perform a behavior. In 30 of the studies, BCT#26 *Prompt practice* accompanied BCT#21. In nine of the interventions BCT#22 *Model or demonstrate the behavior* also accompanied BCT#20 and BCT#21.

Of the 59 interventions, 55 reported positive outcomes at the close of the intervention or in the short-term (i.e., within 3 months) (All interventions except for Abbott et al., 2010; Vadstrup et al., 2011; McGorrian et al., 2015; Villarini et al., 2015). The studies measured behavior change in terms of health outcomes, dietary outcomes, and psychological outcomes. Of the studies, 18 identified short-term behavioral change in relation to health (e.g., reduced cholesterol) (Hermann et al., 2000; McKellar et al., 2007; Pluss et al., 2011; Sorensen et al., 2011; Wunderlich et al., 2011; Archuleta et al., 2012; Balagopal et al., 2012; Carmody et al., 2012; Francis, 2012; Dasgupta et al., 2012; Villarini et al., 2012; Flynn et al., 2013; Penn et al., 2013; Chung and Chung, 2014; Anderson et al., 2015; Fahmida et al., 2015; McGorrian et al., 2015; Poelman et al., 2015), 26 in relation to dietary outcomes (e.g., improved nutritional intake) (Auld and Fulton, 1995; Foley and Pollard, 1998; Hermann et al., 2000; Brown and Hermann, 2005; Newman et al., 2005; McKellar et al., 2007; Shankar et al., 2007; Kennedy et al., 2008; Abbott et al., 2010; Hanson et al., 2011; Wunderlich et al., 2011; Archuleta et al., 2012; Balagopal et al., 2012; Carmody et al., 2012; Bielamowicz et al., 2013; Penn et al., 2013; Rustad and Smith, 2013; Garcia et al., 2014; Goheer et al., 2014; Hearst et al., 2014; Herbert et al., 2014; May et al., 2014; Fahmida et al., 2015; Greenlee et al., 2015; Hossain et al., 2015; Poelman et al., 2015), and 40 in relation to psychological change (e.g., improved nutritional knowledge) (Karvetti, 1981; McMurry et al., 1991; Jacoby et al., 1994; Ranson, 1995; Foley and Pollard, 1998; Keller et al., 2004; Levy and Auld, 2004; Chapman-Novakofski and Karduck, 2005; Woodson et al., 2005; Lacey, 2007; Shankar et al., 2007; Swindle et al., 2007; Wrieden et al., 2007; Kennedy et al., 2008; Clifford et al., 2009; Davies et al., 2009; Abbott et al., 2010; Brown and Richards, 2010; Condrasky et al., 2010; Flesher et al., 2011; Vadstrup et al., 2011; Archuleta et al., 2012; Balagopal et al., 2012; Carmody et al., 2012; Francis, 2012; Bielamowicz et al., 2013; Condrasky et al., 2013; Kitaoka et al., 2013; Rustad and Smith, 2013; Chung and Chung, 2014; Garcia et al., 2014; Goheer et al., 2014; Herbert et al., 2014; May et al., 2014; Mayfield and Graves, 2014; Adam et al., 2015; Anderson et al., 2015; Fahmida et al., 2015; Hossain et al., 2015; Kwon et al., 2015). Long-term positive outcomes (greater than 3 months) were reported in 14 of the 59 interventions (Keller et al., 2004; Brown and Hermann, 2005; Newman et al., 2005; Swindle et al., 2007; Davies et al., 2009; Pluss et al., 2011; Francis, 2012; Flynn et al., 2013; Penn et al., 2013; Garcia et al., 2014; Herbert et al., 2014; Peters et al., 2014; Greenlee et al., 2015; Hossain et al., 2015). Fifty-six interventions contained BCT#1 (information on the consequences of the behavior in general); and BCT#26 (prompt practice). Table 2 illustrates the BCTs identified within each intervention and highlights short- and long-term outcomes.

Table 2. Comparison between the percentage of most commonly occurring BCTs in all 59 interventions and 14 reporting long term behavioral change.

Behavioral Component Technique	Percentage of all 59 Interventions Where BCT was Used	Percentage of 14 Interventions Reporting Long-Term Behavioral Change Where BCT was Used
1 - General information giving	98	64
2 – Information giving specific to the individual	41	21
20 - Where and when to carry out the task	0	28
21 - How to carry out the task	76	71
22 – Demonstrate the task	66	0
26 - Prompt practice/ practical cooking	44	71

For the 14 interventions reporting long-term successful outcomes (based on health, dietary and health outcomes), half ($n = 7$) were conducted in the United States, 3 in the United Kingdom, 2 in Australia, 1 in Indonesia, and 1 in Canada. Samples were of mixed gender for the majority of studies though males exclusively participated in 5 studies. The target population for each of these interventions varied, with no discernible pattern, e.g., some were drawn from the general population, some from specific cultural groups, some low-income and vulnerable groups, and some with specific health needs. The 14 studies stating long-term positive outcomes contained between 4 and 28 cooking sessions with the most common BCTs reported being BCT#26 *Prompt practice,* and BCT#21 *Information on how to perform the behavior,* appearing in 10 out of the 14 studies. The BCT#1 *Providing general information on the consequences of the behavior* was evident in 9 of the studies; and BCT#20 *Relating to information on where and when to perform a behavior* was used in 4 of the studies. *BCT#2 Providing information on the consequences of the behavior specifically related to the individual.* Table 2 highlights the differences between the BCTs which feature more prominently in interventions where long-term outcomes are reported, in comparison to the 59 interventions overall. Table 2 illustrates that practical cooking experience is important in promoting behavioral change rather than watching cooking skill demonstrations that only model behavior and provide direction on how to carry out the skills.

Theoretical underpinning of interventions

Theory was explicitly cited in 14 of the 59 interventions (Auld and Fulton, 1995; Hermann et al., 2000; Levy and Auld, 2004;

Chapman-Novakofski and Karduck, 2005; Newman et al., 2005; Shankar et al., 2007; Swindle et al., 2007; Clifford et al., 2009; Brown and Richards, 2010; Condrasky et al., 2010; Archuleta et al., 2012; Francis, 2012; Condrasky et al., 2013; Adam et al., 2015). However, none of these papers reported how the chosen theory was used in the selection of the specific BCTs employed in the intervention, and no study linked the theory to the content or outcomes. Of the 14 interventions citing a theoretical framework in the intervention development, 9 cited Social Cognitive Theory (SCT) (Hermann et al., 2000; Chapman-Novakofski and Karduck, 2005; Newman et al., 2005; Clifford et al., 2009; Brown and Richards, 2010; Condrasky et al., 2010; Archuleta et al., 2012; Condrasky et al., 2013; Adam et al., 2015); 2 cited Social Learning Theory (SLT) (Auld and Fulton, 1995; Levy and Auld, 2004); 1 cited Experiential Learning Theory (Swindle et al., 2007); 1 discussed Social Ecological Theory (Shankar et al., 2007); and 1 Social Marketing Theory (Francis, 2012). BCT#22 *Model or demonstrate the behavior* was identified in 12 out of the 14 (All except Swindle et al., 2007; Condrasky et al., 2010) interventions citing explicitly a theoretical framework in the methodology. BCT#26 *Prompt practice* was identified in 7 of the 14 theory-based interventions. Of these 7 interventions, 6 involved BCT#22 and BCT#26 together (All except Condrasky et al. 2010). There did not appear to be systematic differences in BCTs identified from explicitly theory-based interventions versus those interventions which did not state a theoretical framework in the design. Of the 14 studies which used theory in the intervention design, all indicated that primary outcomes were met and reported positive short-term gains (i.e., within 3 months). Only 3 out of the 14 studies reporting the use of theory in the design showed long-term positive outcomes (greater than 3 months) (*experiential learning theory* (Swindle et al., 2007)*; social ecological theory* (Newman et al., 2005); *social marketing theory* (Francis, 2012)) whilst 11 of the studies (Keller et al., 2004; Brown and Hermann, 2005; Davies et al., 2009; Pluss et al., 2011; Flynn et al., 2013; Penn et al., 2013; Garcia et al., 2014; Herbert et al., 2014; Peters et al., 2014; Greenlee et al., 2015; Hossain et al., 2015) which reported no theory, evidenced long-term positive outcomes. Therefore, no pattern was identified between theory based interventions, positive long-term outcomes and inclusion of specific BCTs or combinations of BCTs.

Discussion

This study identified and reviewed 59 cooking and food skills interventions in relation to intervention design, identifiable BCTs, theoretical underpinnings, and study outcomes. A more standardized approach with thought given to the theoretical framework underpinning behavioral change may be more likely to promote consistency in the planning of BCTs used and the success of the intervention so that comparisons can be made.

Less than half of the 59 interventions included in this study, contained practical or "hands on" food preparation or cooking elements (coded as BCT#26 *Prompt practice*) as the main focus of the intervention. However, of those interventions reporting long-term behavioral change, the majority included a practical skills element (BCT#26). Those interventions involving cooking demonstration only (BCT#22) reported no long-term behavioral change. It may therefore be surmised that to increase the success rate of cooking interventions and maintain behavioral change in the long term, it is important to empower participants to become involved in practical hands on cooking sessions.

The majority of the interventions (55 out of 59) involved populations in developed countries (31 studies in the United States, 6 studies in the United Kingdom, 4 in Canada, 3 in Scandinavia, 2 in Italy, 2 in Japan, 1 in the Netherlands, and 1 in the Republic of Ireland). Therefore, the results must be considered separately from those involving culturally disparate populations (e.g., South America, China, India, and Indonesia) as replication of the same intervention within a different context may not yield similar results. The majority of interventions targeted vulnerable groups or those with health needs.

The majority of interventions identified between 4 and 10 BCTs which, focus on behavior change related to providing information, or instruction and practice. Furthermore, BCT#1 (information on the consequences of the behavior in general), BCT#21 (instruction on how to perform the behavior) and BCT#26 (prompt practice) appeared across all interventions that were deemed successful in the long term. Furthermore, BCT#2 (information on the consequences of the behavior tailored to the individual), and BCT#20 (information on when and where to perform the behavior) were used in at least half of these successful interventions. Therefore, these BCTs should be used in the future design, planning, and delivery of robust and effective cooking and food skills interventions to promote behavior change.

In addition, the most common BCTs used were related to providing information on the consequences of a behavior generally (BCT#1). Many interventions utilized general information-giving strategies such as providing nutritional education. Previous research has shown that knowledge is required as a basis to generate creativity and the application of skills (Cho et al., 2013), therefore this information sharing can be considered an important constituent of cooking and food skills interventions. However, it is also generally accepted among behavioral science that information alone is not sufficient to change behavior (Campbell et al., 1994). A more holistic set of knowledge and skills related to nutrition, planning meals, food acquisition, and social interaction is required for individuals to change their eating behavior and develop skills in preparing healthy home cooked meals.

In the majority of the interventions where general information (#BCT1) was provided on the relationship between the behavior and its likely consequences, e.g., how a diet high in fats or salt or sugar (HFSS), #BCT2 was also present because the information was tailored to the specific needs of the groups. Such information tailoring can be argued to have a greater impact upon individuals, by increasing personal relevance, thus making behavior change more likely (Michie and Abraham, 2004; Michie et al., 2008).

BCT#26 *Prompt practice* was featured in 39 interventions and captured those instances of carrying out a practical activity (e.g., food preparation/cooking), thereby offering an essential form of skills development in the cooking and food skills domain. Studies in which social learning theory was present

revealed the common use of (BCT#22) demonstration of cooking skills. However, none of the studies using this theory evidenced long-term behavioral change.

Michie et al. (2011) argue that theory-based interventions are more likely to be effective if causal determinants of behavior and behavior change are targeted, but also claim that using a theoretical framework promotes better understanding of why interventions are effective and so create a foundation on which to develop improved interventions (Michie and Abraham, 2004; Michie et al., 2008; Michie et al., 2011). This study where theory was evident, cites social cognitive theory most frequently, however it is apparent through analysis of these interventions that social cognitive theory is not a pre-requisite to determine positive long-term outcomes. Although modeling skills did not promote long-term behavioral change in these instances, it is necessary to consider testing these theories further on a larger sample, or examine an alternative theoretical basis on which to design successful cooking interventions exhibiting long-term behavioral change. As previously mentioned, although theory was explicitly detailed in interventions, they were not linked to specific BCTs indicating that further consideration of BCTs must be incorporated in the planning and design of cooking interventions.

Results indicated that BCT#20 *Provide information on when and where to perform the behavior* and BCT#21 *Provide instruction on how to perform the behavior* were often used together (22 out of 59 studies). The "*Food Cent$*" intervention sessions participants are given information on how to carry out specific food skills (e.g., make a shopping list) (BCT#21) and where to access inexpensive ingredients (BCT#20) (Shankar et al., 2007). Given these results, it would be appropriate to recommend incorporating both BCT#20 and BCT#21 into future CS and FS interventions to maximize the chances of behavior change. Providing instruction on *how* to perform the behavior (e.g., cook a recipe in the group setting) in addition to information on *when and where* to *perform the behavior* within a local community setting or within a personal routine (i.e., replicate the meal in the home environment) helps to increase the personal relevance of the message (Goheer et al., 2014; Greenlee et al., 2015).

BCT#8 *Identify barriers/problem solving* may be of particular relevance for interventions related to the development of practical cooking and food skills, as external barriers such as time, budget and family preferences have been noted as strongly affecting the adoption of new skills and therefore moderating their potential impact upon diet (McGowan et al., 2017; Lavelle et al., 2016b). The inclusion of BCT#9 alongside BCT#8 assists behavior change as participants who have considered their personal barriers and possible solutions, can begin by first enacting small sub-stages of an overall goal (e.g., switching from deep-fat frying sausages to grilling them) before making bigger changes (e.g., replacing the sausages with healthier vegetarian equivalents cooked in the oven).

Strengths and limitations

This research had a number of strengths and limitations. First, this study critically examined a totality of evidence from two recent home-food preparation and cooking intervention systematic reviews which were rigorously conducted and included cooking and food skills interventions from across the globe (Reicks et al., 2014; Reicks et al., Under review). We are confident that given the recency and robustness of these studies, this critique of cooking and food skills interventions has included a representative sample of interventions. The review benefitted from the input of coders who were experienced in the use of BCTs and intervention development and had undertaken extensive training online in advance using the BCT Taxonomy v1 program available from http://www.bct-taxonomy.com/. In addition, it was possible to contact the authors of the taxonomy to seek clarification around any BCT classifications, where there was disparity between coders or ambiguity around taxonomy wording such as for BCT#26 *Prompt practice* which provided rigor to the BCT mapping exercise.

The 40-item CALO-RE taxonomy (Michie et al., 2011) was utilized in this study, however an updated 23-item taxonomy is available (Roberts and Barnard, 2005). The 23-item taxonomy may be suitable for use in offering a more detailed breakdown of a lesser number of studies which potentially may offer a more prescriptive conclusion in terms of effective BCTs for future cooking skills interventions. The BCTs discussed here are based upon the written information which was available in the articles or reports retrieved, and it is possible that additional BCTs were involved in the interventions which were not adequately described in the published reports. However, given the discernible patterns of BCTs identified across multiple and global cooking and food skills interventions, we can be somewhat reassured that the findings indeed reflect the true intervention content. Similarly, in relation to theory, only 14 of the 59 interventions reported explicitly following a theoretical framework in the design of the intervention; yet none discussed this explicitly in terms of their selection of intervention strategies or BCTs. It is possible that theory was employed in the design and selection of other interventions but was not reported, which could lead us to underestimate the true impact of behavior change interventions. It is also worth noting that none of the BCTs identified across all 59 interventions were explicitly described as "BCTs," despite 9 interventions being published following the dissemination of the first BCT taxonomy in 2008. Thus researchers need to be encouraged to use the Michie et al. (2011) CALO-RE taxonomy when designing interventions and share evidence relating to behavior change, regardless of the specific behaviors or the intervention domain.

Finally, it should be noted that despite the reasonable number of interventions used in this examination ($n = 59$), almost all interventions were conducted using developed populations, limiting the generalizability of the results beyond these groups. The scope of this review may be widened to include more recent international cooking skills intervention studies. Furthermore, the findings of the primary studies contained ($n = 59$) were typically self-reported measures, and therefore the usual caution must be noted with regard to social desirability of the findings.

Conclusion

By identifying and highlighting these BCTs and critiquing intervention designs, this paper offers a robust and standardized cooking and food skills intervention design template for future

studies in this area. These findings should facilitate the replication and adoption of effective BCTs into future cooking and food skills interventions to maximize intervention efficacy, with positive impacts on diet quality.

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